SPACE EXPLORATION SYMPOSIUM (A3.)
Space Exploration Overview (1.)

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AUTOMATION OF SPACECRAFT OPERATIONS: NEEDS, RISKS AND OPTIONS

Abstract

The management and operations of spaceflight is a complex and challenging undertaking and requires extremely skilled human staff to plan missions, and to anticipate, investigate and resolve problems during operations. As the human presence in extended beyond LEO, multiple spacecraft may be in long-duration flights or orbiting distant planetary surfaces, along with numerous other habitats and robotic systems. The task of simultaneously managing these assets will become more complex and costly, precluding management using today's large mission operations staff. Interruptions and delays in the Earth-space communications links, the crew's need to make urgent decisions based on available information to remediate faults, and the need to manage resources on a long manned space journey further complicate the spacecraft operational scenario. The use of intelligent control technologies that allow space systems to operate autonomously or with progressively reduced/selectable human supervision, introduces its own risks and implementation challenges. The major cultural obstacle stems from the conflicting views of mission operations staff and crew on the migration of automation functionalities into spacecraft operations. The consensus is that the human element should always be part of the automation strategy, for no matter how good the automation, it cannot match human creativity, knowledge or training. The technology to be developed has its own risks: 1) Safety (Verification & Validation) of a given functionality is difficult to evaluate, 2) Costs and benefits are hard to quantify, 3) Development and validation costs readiness timelines for infusion are difficult to estimate reliably, 4) Software reliability in infrequently used, hard to test functionalities, is difficult to ensure, and 5) It is difficult to predict an automated system's response in unexpected situations. Funding an automation technology development program has its own challenges, especially in the environment of dwindling technology dollars. At this point it must be kept in mind that some automation of operations, such as delay- and interruption-tolerant networks for Earth-space communications links, enabling crew decision-making in the presence of on-board faults, and maintaining and managing a hibernating space craft in a distant planet's orbit or on its surface while it is unoccupied, can not be deferred, if we want to realize our vision of enhanced human presence in space. Secondly, retrofitting a manually controlled spacecraft for any degree of automation is costly, time-consuming, and, in certain cases, counter-productive. The key is to ensure crew- and operator-adjustable automation are part of the initial requirements, design automation into the systems and concepts of operations up-front, and stipulate adequate software testing to ensure that software works as required. Intelligent software design and software certifications teams must work in tandem. In the light of above facts the paper examines the priority automation needs, the risks associated with their implementation, and options to mitigate theses risks.